COMBAT RATION NETWORK

FOR

TECHNOLOGY IMPLEMENTATION

Retort Racks for Polymeric Trays in 1400 Style Spray Retorts

Final Technical Report STP 2010

Results and Accomplishments (July 2002 - May 2003)

Report No: FTR 202

CDRL Sequence: A003

May 2003

CORANET CONTRACT NO. SPO103-02-D-0024

Sponsored by:
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*A New Jersey Commission on Science and Technology Center

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
August 2003	Final	September 2002 - May 2003

4. TITLE AND SUBTITLE
Retort Racks for Polymeric Trays in 1400 Style Spray Retorts

5a. CONTRACT NUMBER
SP0103-02-D-0024 / 0005

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Henderikus B. Bruins

5d. PROJECT NUMBER
STP # 2010

5e. TASK NUMBER

5f. WORK UNIT NUMBER
A003

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Rutgers, The State University of New Jersey
The Center for Advanced Food Technology
Cook College, NJ Agricultural Experiment Station
New Brunswick, NJ 08903

8. PERFORMING ORGANIZATION REPORT NUMBER
FTR 202

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Logistics Agency
8725 John J. Kingsman Rd
Fort Belvoir, VA 22060-6221

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution Statement A. Approved for public release. Distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The objective of this project was to design a retort rack that would maximize the retort capacity of a 1400 style spray retort and to select a material that would widthstand the harsh retort spray environment. The contract consisted of three phases: I) mold design, II) mold fabrication, III) rack production. Test rack samples were produced at the end of phase II using three different materials. A blend of Polyphenylene (PPE) and Polypropolyne (PP) with 15% short glass fiber filling was selected as the preferred material for the production of the final set of racks.

Two ration producers were supplied with 100 retort racks each, for testing in a production environment. The racks increased the capacity of the retort with 29-33% and the rack material has widthstand the retort environment without any problems after exposure to three-month of production environment.

15. SUBJECT TERMS
Retort Rack, Spray Retort, Injection Mold

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	19b. TELEPHONE NUMBER *(Include area code)*
Unclassified	Unclassified	Unclassified	Unclassified	12	Henderikus B. Bruins	732-445-6130

Abstract

The polymeric half steam table tray requires a support structure during the retort process that will cary its weight and allow the heating media to freely flow around the container. One such rack was developed specifically for a Stock 1100 full water immersion rotational retort.

That particular rack is widely used by the ration producers even in retort systems other than the retort for which it was designed. To accommodate other retort systems, some adjustments in rack height had to be made to facilitate the heating media flow in spray type retorts. The capacity of these alternate retorts (FMC 1400 spray retorts) is however under utilized by use of these racks. Also, the spray retort is a much harsher environment for the retort rack and requires a different type material than used in full water immersion retorts.

The objective of this project was therefore to design a retort rack that would maximize the retort capacity of a 1400 style spray retort and to use a material that would width stand the much harsher spray environment.

This project was based on a competitive solicitation and award of sub contract. ALLPAX was selected as the preferred vendor based on best overall value. Their sub-contract consisted of three phases: I) mold design, 2) mold fabrication, 3) rack production. Test rack samples were produced at the end of phase II using three different materials. All three materials passed the acceptance test, ALLPAX selected eventually a blend of Polyphenylene (PPE) and Polypropolyne (PP) with 15% short glass fiber filling as the preferred material for the production of the final set of racks. The resulting material offers unique balance of stiffness, impact strength, temperature resistance, elongation and low specific gravity.

Two ration producers were supplied with 100 retort racks each, for testing in a production environment. The racks increased the capacity of the retort with 29-33% and the rack material width stand the retort environment without any problems three-month of production environment.

1. Results and Accomplishments

1.1. Introduction and Background

The main objective of this project was to increase industry retort capacity for the polymeric trays. The ration producers were using a retort rack that was specifically developed for the GFE STOCK 1100 and 1300 retorts. A retort that is available to ration producers to supplement producers own retort equipment, to meet surge and mobilization requirements.

Several producers have, however, retort equipment other than those GFE STOCK retorts. Their retorts are generally larger in size, and can accommodate more trays in each cart, plus they might operate in a steam, or water spray mode, rather than having the trays completely immersed in hot water. Prior to this project, those producers did not have access to properly sized retort racks, that would maximize the capacity of those larger retorts. This limited the available production, and thus the overall surge capacity

The design of an injection mold for retort racks is depended on many variables. The flow rate, the direction of flow and the type of heating media can all have significant effects on the design of the rack. Also the selection of the rack material is a function of the above mentioned factors. Spray retorts have a tendency to be harsher on the molded racks than steam/air and/or full water immersion retorts. Also the rack needs to be significant stronger in other than full water immersion retorts due to the lack of container buoyancy.

This project designed and fabricated, an injection mold specifically sized for FMC 1400 spray type retort and evaluate various rack materials to determine durability of the rack in a production environment. This project was executed in cooperation with Stegner Food Products Company and The Wornick Company, two ration producers located in Cincinnati OH, that use the larger FMC 1400 spray retort. The actual design and fabrication of the injection mold and production of racks was awarded to ALLPAX Products Inc, after a competitive subcontract solicitation.

1.2. Objectives

The overall objective of this project was to design and fabricate an injection mold that can be used to mold retort rack. This new rack needs to fit the FMC 1400, a retort size that is being used by two of the three polymeric tray ration producers (Stegner and Wornick). The new retort rack needs to increase the retort capacity, compared to current used racks, have acceptable heat distribution characteristics, and withstand normal handling by Wornick and Stegner.

The sub objectives were:

- To identify and document the rack design configuration needed for efficient retort racks to be used for poly trays in the FMC retorts used by Stegner and Wornick.
- To work with Stegner and Wornick to identify all requirements to be met by the new racks to be acquired.
- To develop a specification suitable to the producers, and solicit for mold makers to competitively bid on producing the mold that meets the requirements. Include initial limited runs for “first article” examination and testing, and arrange provisions for running more than one type of polymeric mold material, possibly as a result from a separate project.
- To acquire two complete sets of retort racks, install, and readiness test at each producers retort and report on readiness to be shipped out as intended.

1.3. Results and Conclusions

Due to the world tension (Iraq) and the need for additional retort capacity, this project was put on a fast track. Once the sub-contract was signed between ALLPAX and Rutgers on November 5, 2002, this project

had top priority. ALLPAX and it's sub-contractors worked on the design of the injection mold during the Christmas Holiday Season and started to mold the first parts beginning of February. Final set of racks were fabricated on April 15 , 2003

Both Wornick and Stegner were involved in development of the specification for the retort rack, the selection process of the sub-contractor and the design features of the rack. While initially the rack testing was scheduled to be done at Wornick, and limited access their production retorts and availability of properly sized retort rack pallet bottoms, led to shift in testing location to Stegner Foods. All tests were conducted as soon as racks were made available by ALLPAX, with the help of John Rynberg, Director of Technical Services of the Stegner Food Products Company and in-house process authority. Final acceptance tests were performed on April 29, 2003 after which time Stegner switched over their entire ration production to this new rack, allowing them to increase their capacity by 33%. Wornick's retort capacity increased with 28.5%, slightly less due to some differences in geometry of the retort.

Selection of the retort rack material was an important facet of this project. ALLPAX tested three materials and selected eventually a blend of Polyphenylene (PPE) and Polypropylene (PP) as the base material filled with 15% glass fiber. According to ALLPAX, the resulting material offers unique balance of stiffness, impact strength, temperature resistance, elongation, and a low specific gravity. It is anticipated that this material has a much longer useful life time than the polypropylene/glass fiber material blend used in the older Stock 1100 rack.

1.4. Recommendations

Even though, the rack material selected by ALLPAX appears to have excellent quality characteristics, the material is also significant more expensive and requires a higher tonnage molding machine than the cheaper polypropylene, increasing the cost of the rack. The application for the polymeric tray in a spray retort is quite demanding due to the size and weight of the container and the high spray water velocities in larger retorts. Work is ongoing at Texas A&M to identify better and cheaper plastics for retort rack application. They have developed a material that appears to perform well in full water immersion retorts. However, their materials might need to be adapted to the to spray retort applications. Once new materials have been identified, it is recommended that a minimum of 50 racks is molded and exposed to the spray retort environments, while monitoring rack quality.

2. Program Management

The project was awarded on September 2, 2002 under contract SP000103-02-D-0024, delivery order 0005 with a total obligation of $143,834. Performance period for this delivery order was originally set for 3/31/03.

The following modifications were issued:

Date	Modification	Description
10/25/02	0005/01	Modification of the Item No from 0002 to 0007
3/28/03	0005/02	Performance period extended from 3/31/03 to 5/31/03 and additional funding committed in the amount of $13,881 to cover the incremental cost for the accelerated fabrication schedule.

3. Short Term Project Activities

3.1. Phase I, Preliminary Engineering

3.1.1. Planning

Rutgers developed, in cooperation with Stegner Food Products Company and The Wornick Company, a project management plan, identifying each individual task and key contacts at the two participating companies. Stegner and Wornick are two ration producers that have FMC spray retorts and would be able to test and use the racks to increase their capacity.

3.1.2. Selection Potential Sub Contractors

In cooperation with Stegner and Wornick, four potential companies were identified that have the capability and experience to design, fabricate and mold retort racks. The companies were:

- ALLPAX Products, Att: Scott Williams, Franklin, WI 53132
- Pioneer Plastics Inc, Att: Jim Kunkel, Dixon KY 42409
- Stock America, Att: Dave Polvino, Cary, NC 27513
- WRH Industries, Att: Warren Hartwell, Fall River, MA 02720

3.1.3. Solicitation

In cooperation with Stegner, Wornick and DSCP, technical specifications, including test protocols and acceptance criteria were prepared for the retort rack. This specification was then issued as a Request for Proposal by Rutgers University (appendix **4.1)** and sent to the four potential contractors on August 13, 2002. Proposals were due by September 6, 2002 @ 2:30 pm.

3.1.4. Evaluation Bid Proposals

Three bid proposals were received by the due date. All three proposals were evaluated by Rutgers, Stegner and Wornick. ALLPAX's proposal was selected unanimously, based on "best overall value" (see appendix **4.2**)

The results of the evaluation was presented at an IPR meeting at the CORANET Workshop #4, Athens GA, on September 24, 2002. DSCP/DLA recommended to include an economic price adjustment and a more detailed description of the warranty clause for racks. ALLPAX agreed to the revised clauses, which were then included in the sub contract document.

The final sub contracting document was reviewed by DSCP/DLA and fully executed on November 6, 2002 (appendix **4.3**)

3.2. Phase II, Fabrication and Evaluation

3.2.1. Design of the Injection Mold

A kick off meeting was held between ALLPAX, Rutgers, Stegner and Wornick, on November 15 at Wornick's facility in Cincinnati. At this meeting design specifications, concept solutions, testing protocols and rack materials were reviewed and discussed. Rutgers reviewed various alternate rack configurations to ALLPAX's suggested column stack configuration. The alternate designs were based on offset stacking of the containers, forcing water flow in between the containers, a feature that could improve the temperature distribution performance, while minimizing clearance between containers and maximizing retort capacity. However, offset containers stacking would require reverse stacking of every other racks and male/female stacking pins to enforce the stacking requirments. While Stegner and Wornick recognized the benefits of the alternate stacking solutions, neither of them felt comfortable to implement reversed stacking on the plant floor as it would require additional labor skills. It was, therefore, decided to base the design of the rack on the original column stack solution. See appendix **4.4** for additional details and meeting notes.

A design review meeting was scheduled between the various parties on December 6, 2002 to review the first drawings from ALLPAX. Minor design changes were requested such as finger access holes placed in

race ring seal area, gusset supports on main support walls, taper on I-beams, and larger stacking posts and receptacles. Major design changes included addition of exterior openings around tray perimeter to increase flow, placement of additional window openings in center tray wall, and of most significance a reduced rack height and associated flow channels. This last item was significant, as it would allow the users to gain additional capacity, but might reduce temperature distribution performance. It was agreed between Wornick, Stegner and ALLPAX, that if this reduction in height did not allow the rack to meet requirements for Temperature Distribution, any mold changes and cost required to the tool would be split equally between Wornick and Stegner. See appendix **4.5** for additional details and meeting notes.

The input from the review meeting was used by ALLPAX to update the drawings which were re-submitted on 12/16/02 for review. Approval to start phase II of the subcontract: "fabrication of the mold" was issued by Rutgers on 12/16/02 and ALLPAX was requested to expedite this phase. On 12/17/02, ALLPAX released the drawings for final model processing. This last engineering stage was completed on 12/22/02. Design was released for both FEA (Finite Element Analysis) study and mold manufacturing on 12/23/02.

3.2.2. Fabrication of the Injection Mold

Based on the request to expedite the schedule, ALLPAX submitted an incremental cost proposal ($13,880) that would reduce the fabrication time line by 3 to 4 weeks. A subcontract modification was issued to ALLPAX on 12/20/02 increasing the total award of the subcontract to cover the incremental cost. Mold manufacturing began on 12/23/02,continued through the holidays with the exception of Christmas Day and New Years Day and was completed on January 24th, . The size of the finished part (final part weight), and the materials to be used, required higher mold tonnage than originally anticipated by ALLPAX. The mold was finally sized to run in a 3500-ton press, which required extra parts to insure mold integrity. The 3500 ton press is a more expensive machine to produce rack, which will have a negative impact on the cost per rack.

After evaluation of the first set of rack samples at Stegner, the mold required fine-tuning. The initial trials indicated a higher than acceptable deformation of the racks. One of the reasons for this, according to ALLPAX, was the lack of ejector pins in the floor of the rack. Specification requirement did not allow ejection pins to be located anyplace that the lid stock material of a tray may come in contact with. By only allowing the ejection pins to “push-off” on the wall area of the tray, the floor compartments of the tray had a tendency to stick into the mold a bit and begin curing with a sag in them right off the tooling. To help counteract this, four ribs were added to the underside of the tray. Ejection pins were then added to push against these ribs to help remove the tray from the mold. In addition, 12 vertical gussets were added on the topside of the tray. As well as strengthening the tray, these gussets will help hold the wall in place during cooling and curing phase.

After evaluation of the second set of racks samples at Stegner, deformation of the floor compartments of the tray after retorting was still higher than acceptable. After careful rack height analysis, it was concluded that the deformation was caused by slight height differences of the main load bearing points of the rack. These height differences accumulated as function of the stack height and lead to a noticeable deformation in the top layers of the stack. It was theorized that unequal shrinkage of the molded rack caused the height of the support “I” beams to be less than the side walls. ALLPAX decided to increase the height of the “I” beams in the mold with 0.3 mm and to add additional gussets to the bottom side of the tray as well to compensate for this shrinkage. It should be noted however that the shrinkage of the rack after molding is a function of the rack material used and that these adjustments were specifically made to compensate for the shrinkage behavior of the PPX-615 material

This last set of modifications was sufficient to reduce the deformation of the rack to an acceptable level as tested on the PPX-615 material. The mold geometry was accepted by Wornick and Stegner, and ALLPAX was requested to produce 200 racks for production testing.

A copy of the final rack drawing is attached in appendix **4.9**. For future reference, the mold I.D. # is 577, which is directly embossed on each rack molded. The material reference code that was used for the production set of racks is PPX615. The ALLPAX part number for this rack is TRA-RCK-02 which is specific to this mold, PPX615 material, and gray color.

The mold will be stored by ALLPAX or it's subcontractor, in a fully assembled state. Individual main mold parts consists of the following components:

- Machined "A" plate
- Machined "B" plate
- 4 drop hot runner manifold system complete with heaters
- ejection system spring loaded for auto extraction of molded trays
- backup plate & support pillars to allow 35" shut height as required by most 3500 ton molding machines
- dedicated mounting rails for installation into mold machines

3.2.3. Fabrication Retort Racks

3.2.3.1. Retort Rack Material

For trial purposes ALLPAX selected 3 materials as the base resins.

- TPG – 20 % short glass filled – PP based resin
- PPX615 - 15 % short glass filled – PPE / PP alloy
- PPX630 – 30% short glass filled – PPE / PP alloy

Coupons (sample materials) of the PPX615 & PPX630 materials were supplied by ALLPAX and installed in retort systems at both Stegner & Wornick. Stegner ran 70 cycles prior to removing and Wornick ran about 140 cycles during the same period. Analysis on coupons showed no sign of degradation according to ALLPAX.

The TPG material has an attractive price point and strength combined with it supple finish for eliminating cosmetic blemishes. The PPX materials were chosen for its characteristics. The base alloy is a blend of Polyphenylene (PPE) and Polypropylene (PP). The resulting material offers unique balance of stiffness, impact strength, temperature resistance, elongation, and a low specific gravity, according to ALLPAX.

The PPX615 material was eventually selected by ALLPAX for the production samples due to the better expected performance compared to the TPG material and lower cost compared to the PPX630 material. The price of the PPX material ($1.35/lb) was however higher than the TPG material ($0.85/lbs) which was the material used by ALPAX in their sub-contract proposal. The incremental material cost for the rack ($1,590) was claimed by ALLPAX under the economic price adjustment clause.

3.2.3.2. Initial Rack Samples

The initial set of racks were molded on February 7 and shipped directly to Stegner and Wornick for retort testing. Under the subcontract, ALLPAX provided 3 samples of each material to Rutgers for testing. Each producer purchased additional racks for temperature distribution performance tests. Both Wornick & Stegner received full cubes of the TPG and the PPX630 materials and one (1) cube of the PPX615 material was delivered to Stegner, while six (6) samples of the PPX615 material were sent to Wornick for evaluation. These additional samples permitted both companies to conduct temperature distribution studies on single stacks and provide feedback to ALLPAX if they needed to increase the rack height.

While the initial test was scheduled to take place at Wornick, only Stegner had retort pallet bottom available that could support testing of a cube of racks. Therefore the acceptance test site for the racks was performed at Stegner.

3.2.3.3. Second Set of Rack Samples:

Based on the test results from the initial set of racks, mold changes were made and additional racks from each material were molded on 2/28/03. ALLPAX optimized the molding process conditions to minimize

rack deformation and maximize production rate. The second set of racks was sent to Stegner and tested on 3/6/03. Detailed rack height measurements were made to pinpoint the cause for rack deformation in the upper layers of the stack. It was concluded that the deformation in the upper layers was caused by unequal height of the rack in the load bearing support points.

3.2.3.4. Final Set of Racks

ALLPAX selected the PPX-615 material for the production of the final set of racks (200). Production took place on April 15, 2003. These racks were manufactured in a “grey” color and date marked “March 2003”. The subcontract requires that ALLPAX warrantees these racks for one year of continuous use.

3.2.4. Performance Testing

3.2.4.1. Initial Test

The retort tests on the initial set of racks were conducted on February 10 at Stegner by Rutgers University and witnessed by ALLPAX. All three rack materials were processed twice, fully loaded, at 260 F for 1 hr. The racks were then evaluated for deformation (sag) and impact resistance (drop). (see appendix **4.6** for a detailed trip report)

The FMC spray retorts use pallet bottoms on which the racks are stacked. The racks need to be self stacking, as no side support is given by these pallet bottoms. Also, the pallet bottoms need to have adequate open space to facilitate steam and water flow through the stack of racks, but need to be strong enough to support a fully loaded stack of racks in its main load bearing points . After the initial test, recommendations were made to Stegner, to increase rack support in their pallet bottoms to minimal stresses on the rack. It was also recommended that modifications would be made to avoid any contact or stress to the racks from the loading and unloading chain installed in the retort.

The initial test demonstrated a higher then expected deformation of the rack which was a function of the rack position in the stack. The least amount of deformation was observed in the bottom layers and the most amount of deformation was observed in the top layers. Also, outside walls “toed-in” near the top of the wall and the "toe-in" was greater again at top of tray cube

Based on the results of the initial trial, ALLPAX made modifications to the mold, allowing the rack to be ejected easier during the molding process and increasing the stiffness of the rack by adding additional runners and gussets to the rack.

3.2.4.2. Second Test

On March 6-7, retort tests were again conducted by Rutgers University at Stegner on a second set of racks. (see appendix **4.7** for a detailed trip report).

Again all three rack materials were processed twice, fully loaded, at 260 F for 1 hr. At this time, Stegner had modified all their pallet bottom plates to support the rack in all load bearing points and in addition, Wornick send two of their bottom plates to Stegner for a comparison test.

The racks were then evaluated for deformation . Again, rack deformation became increasingly larger to the top of the tray cube. When the tray position was reversed within the stack, the deformation was fully reversible. Measurements confirmed that the deformation was caused by slight differences in rack height in the load bearing points and not due to softening of the material (heat sag). Recommendations were therefore made to ALLPAX to increase the height of the specific load bearing supports with 0.3 mm in order to minimize the rack deformation within a stack.

After the second retort cycle, racks of each material type were selected for a multiple drop test. All three materials passed the drop test

Both Stegner and Wornick conducted temperature distribution studies on full stacks of racks, using their in-house capability. Stegner was satisfied with the performance of the rack as indicated in a memo to Rutgers from John Rynberg, Stegners in-house process authority:

I have completed several temperature distribution studies using the new military rack from AllPax. The studies conducted in the FMC retorts, both 1400 static and 1400 rotational in static mode, indicate that our come-up time profiles currently used with the existing Stock racks are sufficient to produce acceptable distribution results with the new racks. Our programmed come-up profile does not exceed 15 minutes for either type of retort.

Wornick was not as satisfied with their temperature distribution data and contemplated for a long time if they wanted to increase the height of the racks and reduce retort capacity. This option and associated cost was negotiated between Wornick, Stegner and ALLPAX during the December 6 design review meeting (see appendix 4.5). On March 21, Wornick accepted the performance of the rack as indicated by e-mail from Jody Weil:

Based on our temperature distribution testing, Wornick accepts the current rack design eventhough we exceed the 15 minute CUT as specified in the subcontract.

Following that e-mail on March 21, ALLPAX was given the go-ahead to proceed with phase III and mold the 200 racks per current configuration.

3.2.4.3. Final Test

ALLPAX modified the rack slightly based on observation from the previous test. The modifications were to further strengthen the side walls of the rack and adjust the height of specific load bearing points in order to minimize the deformation of the rack in the upper layers of a stack. The test on the final set of racks (PPX-615) was conducted by Rutgers University at Stegner on April 29-30. One cube of racks was processed twice, fully loaded, under 260 F for 1 hr.

The sag of the rack due to heat creep as observed in the lower racks was less than the required maximum 3 mm. The deformation in the top layer racks was significantly reduced by the adjustment of the load bearing points. The rack design has build-in flexibility to allow self-adjustment and distributes the weight evenly over all load bearing points. The deformation is fully reversible when the location of the rack is changed.

All three racks tested for impact resistance passed the ten(10) sided drop test from 24 inches height.

Stegner Foods indicated to be satisfied with the performance of the rack and switched their production over to these new racks. The new rack will increase their retort capacity with 33%.

The Wornick Company is proceeding to implement the change over of their production to these newer racks. The new rack will increase their retort capacity with 28.5%, slightly less than Stegner's capacity due to some differences in retort and pallet bottom geometry

4. Appendix

4.1. Request for Proposals

4.2. Proposal Evaluation

4.3. Sub Contract

4.4. Trip Report #1, Kick Off Meeting (11/15/02)

4.5. Trip Report #2, Design Review Meeting (12/6/02)

4.6. Trip Report #3, Initial Rack Test (2/10/03)

4.7. Trip Report #4, Second Rack Test (3/6/03)

4.8. Trip Report #5, Final Rack Test (4/29/03)

4.9. Final Rack Drawing